Research on the Influence of Digital Inclusive Finance Based on ANN-MLP Algorithm on Real Economy Development in Beijing

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Abstract: With the convergence of digital technology and finance, digital inclusive finance has become a big trend. The Digital Inclusion Finance Index is also widely used to measure the real economy. This paper firstly analyzes the current financial index system of digital inclusion in Beijing. Secondly, five indicators are selected: thereal economy gross product, fixed asset investment, regional industrial value added as a proportion of regional GDP, power generation and freight volume to construct an index system of real economy development. Then, the application of neural network-multi-layer perceptron (ANN-MLP) algorithm is used for empirical analysis, and it is considered that the comprehensive system established in this paper is more concise. The results show that for the real economy as a whole, the index system of the real economy in Beijing is more concise and accurate. The results show that the importance of digital inclusion finance for the real economy is reflected in the breadth of its coverage, and the development of digital level plays a vital role in most indicators. The digital level promotes the development of the real economy by reducing the liquidity constraints of consumers and SMEs, improving financing efficiency, expanding access to financing, reducing financing costs, and facilitating consumer and enterprise payments.

1. Introduction

With the continuous integration of digital technology and finance, financial transactions and service models are evolving, and digital, mobile and intelligent digital inclusive finance is becoming a major trend. In the epidemic environment of 2020, China's contactless, uninterrupted and efficient digital inclusion finance plays an important role in fighting the pandemic and helping small and micro enterprises and other real economies, but there is little research in this area.

In the past few years, China's digital finance has made great progress and exerted great influence on the global scale (Huang& Huang, 2018, 1489). To this end, a team of researchers from Peking University's Digital Finance Research Center and Ant Group Research Institute has compiled a set of "Peking University Digital Inclusion Finance Index" (Guo et al., 2020, 1401-1418) since 2016, using Ant Group's massive data on digital financial inclusion. The purpose of the index is to provide a comprehensive set of tools for industries to reflect the status and evolution of digital inclusion finance without compromising the privacy of financial consumers and the trade secrets of financial institutions (Chen, Sun& Xu, 2015, 72-81). Since then, the Digital Inclusion Index has been used to measure various areas of China's economic development. For example, Cai Hongyu and Yang Chao used it as evidence of credit availability and resident poverty alleviation (Cai& Yang, 2021, 24-30). Yi Xingjian and Zhou used it to determine whether digital inclusive finance has significantly affected resident consumption (Yi& Zhou, 2018, 47-67). Ren Biyun and Li Liuying used it to measure whether digital inclusive finance promotes inclusive rural growth (Ren& Li, 2019, 3-14). Chen Xiaolong analyzed research on the development of digital inclusive finance in Inner Mongolia in 2021 (Chen& Qiao, 2021).

In order to breakthrough innovation and enrich the digital inclusive finance system, we introduced some new indicators to improve the digital inclusive finance index. We use a neural network-multi-layer perceptron (ANN-MLP) to select indicators that accurately reflect the real economy, combined with the Digital Inclusion Index, and chose Beijing to test whether the new indicators are reasonable. Firstly, this paper analyzes the five indexes of Beijing's fixed-asset investment in GDP and the proportion of Beijing's fixed asset investment in GDP, and constructs the index system of real economy development. On this basis, the ANN-MLP algorithm is applied to empirically analyze that the comprehensive system established in this paper is more concise and accurate in measuring Beijing's real economy. At the same time, empirical analysis shows that the comprehensive system can measure the development of Beijing's real economy more succinctly and accurately.

2. Status of Beijing Digital Inclusive Finance Index

2.1 Beijing Digital Inclusion Financial Index System

According to the Principle of Digital Financial Inclusion Index System of Peking University (Guo et al., 2020, 1401-1418):

(a) Considering both breadth and depth;

(b) Considering vertical and horizontal comparability;

(c) Reflecting multi-layered and diversified financial services.

The system index design is shown in Figure 1.

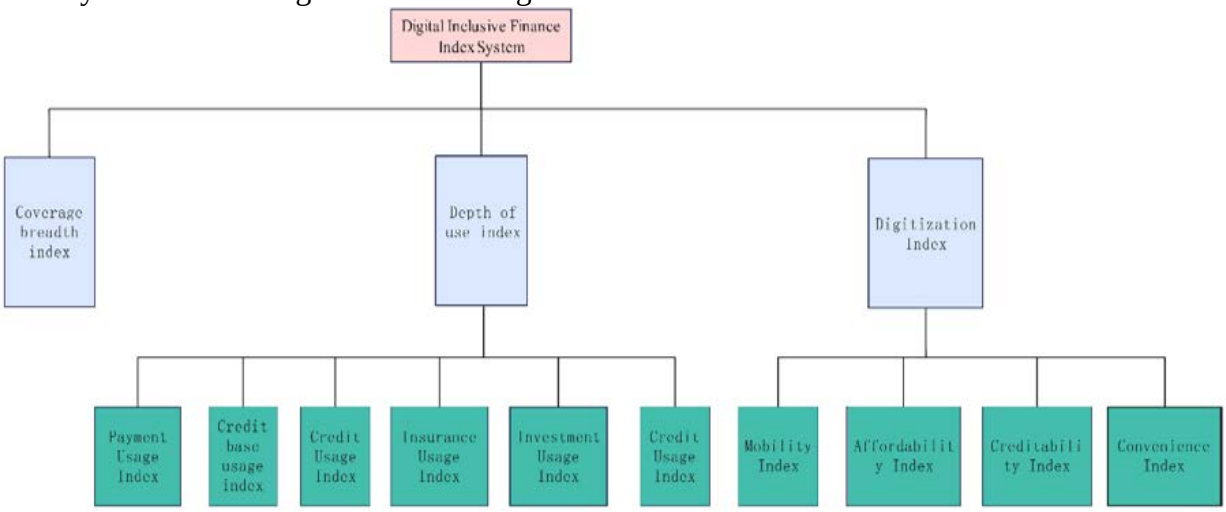

Fig 1. Digital Inclusion Index System.

2.2 Total Digital Inclusive Finance Index Analysis

Data for this study are mainly from the China Statistical Yearbook, the China Provincial Statistical Yearbook, and the National Bureau of Statistics website. Data are derived from the Digital Inclusion Finance Index calculated by the Peking University Digital Inclusion Financial Center. (Guo et al., 2020, 1401-1418)

First of all, from the overall index, as shown in Figure 2, digital inclusion finance in Beijing shows a steady development, relatively speaking. During the initial stage of Internet finance development (2011-2013), Beijing's inclusive finance showed a more obvious upward trend, and then showed a stable growth trend.

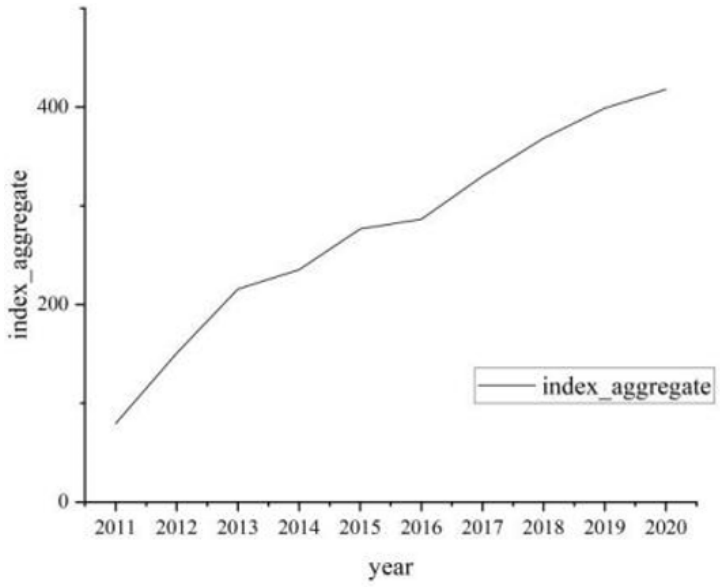

Fig 2. Beijing Total Digital Inclusive Finance Index from 2011 to 2020 (Provincial Data).

2.3 Comparative Analysis of Different Dimensional Indicators of Digital Inclusive Finance

From the perspective of the three dimensions of digital inclusion finance, the digital index of digital inclusion finance is at a high level of development in both breadth and depth. After 2013, digital inclusion finance showed a stable trend in breadth and depth. After 2013, the digital inclusion finance depth index showed a slight decline and relatively slow growth in the later period, as shown in figure 3. The development of depth of use should be focused on, which is conducive to the continuous promotion of the in-depth development of inclusive finance research. (Chen & Qiao, 2021)

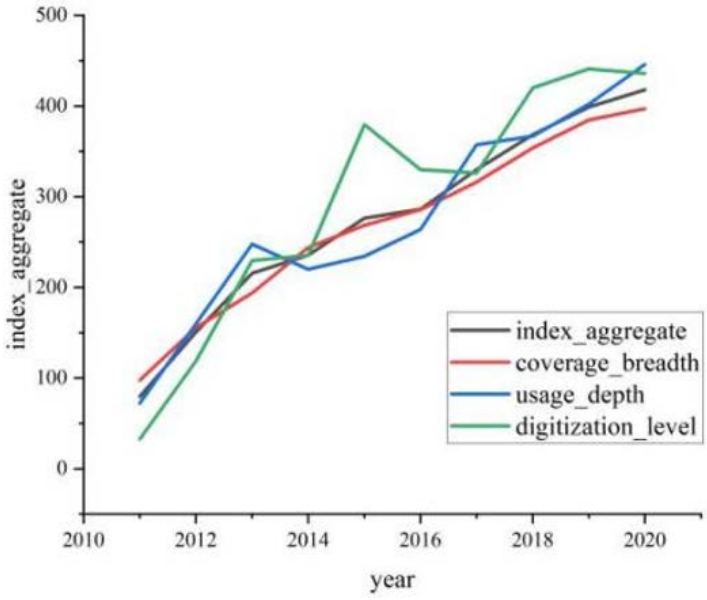

Fig 3. Comparative Analysis of Different Dimensions of Financial Inclusion in Beijing, 2011-2018.

3. Construction of Regional Real Economy Development System

3.1. Overview of the real economy

The real economy in a narrow sense refers to manufacturing, and the real economy in a broad sense refers to all sectors and industries engaged in productive service activities except real estate and finance (Zhang&Wen,2020,47-66), including manufacturing, agriculture and service sectors, which represents the total value of products and services produced by a country or region. The real economy

is the material guarantee of people's lives and an important part of the economy, as well as the real source of wealth and the driving force of the country's sustained strength. Developing the real economy well is conducive to enhancing economic resilience and promoting high-quality economic development. Since the Nineteenth National Congress of the Party, the Party Central Committee, with Comrade Xi Jinping at its core, has attached great importance to the development and growth of the real economy, and has proposed that "the focus of economic development should be on the real economy". The importance of making the real economy stronger has become a key part of national planning. For the economy to develop steadily, the government must pay attention to the development of real economy and prevent the economy from moving from real to virtual.

3.2. Real Economy Development Indicator System

With such a high status of the real economy, its measurement indicators are also critical. Many common indicators are reflecting the development of regional real economy, such as GDP, PMI, real industrial value added, regional power generation, railway freight volumes, employment level, fixed asset investment, etc. In this paper, we use "gross real economic product" as an indicator to measure the size of the real economy, which is expressed by the GDP of each province minus the value added of the financial sector and the value added of the real estate industry (Chen, 2021). Real economy development reflects the general trend and process of changes in the size of the real economy in a region, and the real economy growth rate reflects the overall level of real economy development (Fan& Zhang, 2022). Since the growth rate of real economy investment is not included in the official statistical caliber, we can get the fixed asset investment index data from the official. Fixed-asset investment is the basis for the steady development of the national economy and the core indicator for the operation and development of the real economy. Investment in the real economy is mainly in plant, equipment, and other capacity aspects. Hence, investment in fixed assets and its disaggregated items can well reflect the specific investment direction of the real economy, thus reflecting the growth rate of the real economy. Therefore, this paper takes fixed asset investment as an important index to measure real economy development. The secondary industries include mining, manufacturing, electricity, gas and supply, and construction, etc. All these industries contribute a lot to the real economy, so applying their related indices can also reasonably reflect the development level of the real economy. To this end, the paper adopts the research method commonly used by mainstream scholars, and uses the proportion of regional industrial value added to GDP rather than the proportion of secondary industrial value added to GDP as an indicator to measure the overall level of regional real economic development (Yang& Gu, 2021). At the same time, railway freight volume and electricity generation capacity are two very important indicators to measure the level of real economic development.

Therefore, a total of five indicators have been selected, namely, gross real economic product, fixed asset investment, regional industrial value added as a share of regional GDP, power generation and railway freight volume. Construct the real economy development index system, judge the degree of the influence of digital inclusive finance on real economy development by analyzing the influence of digital inclusive finance on real economy development, as shown in Figure 4.

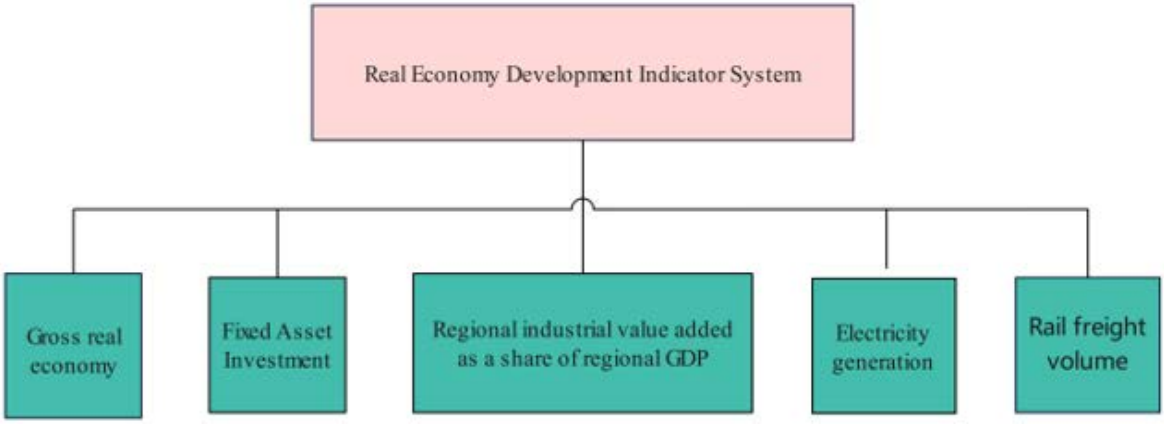

Fig 4. Real Economy Indicator System.

4. ANN-MLP

4.1. Introduction of ANN

Artificial neural network (ANN) is a complex network composed of many interconnected nodes (neurons). It abstracts, simplifies and simulates the human brain's organization and operation mechanism from the angle of information processing. Neural network is a nonlinear information processing system based on the structure and function of neural network. Artificial neural network has the characteristics of self-adaptation, self-organization, and self-learning, and has strong nonlinear function approximation ability and fault tolerance. It can be used for classification, simulation, fuzzy control, prediction and impact studies, etc. It is a powerful tool to deal with nonlinear systems. Common artificial neural network models include BP neural network RBF radial basis function network and so on.

Artificial neural networks are divided into single and multilayer, in which each layer contains several nodes (neurons), and each node represents a specific output function, known as an activation function. Each connection between the two nodes represents the weighted value of the signal passing through the connection, known as a weight. The neural network gradually adjusts the connection weights of neurons to process the information and simulate the relationship between input and output through the repeated learning and training of input data. It does not need to know the exact relationship between input and output, nor does it need to rely on a large number of parameters, as long as it understands that unconstant factors (unconstant parameters) cause output information to change. Compared with traditional data processing methods, ANN has obvious advantages in processing fuzzy data, random data and nonlinear data. It is especially suitable for large-scale, complex systems with unclear information. Therefore, it is of great value to use artificial neural network to study the influence of financial inclusion on the development of the region's real economy. The conventional neural network is shown in Figure 5:

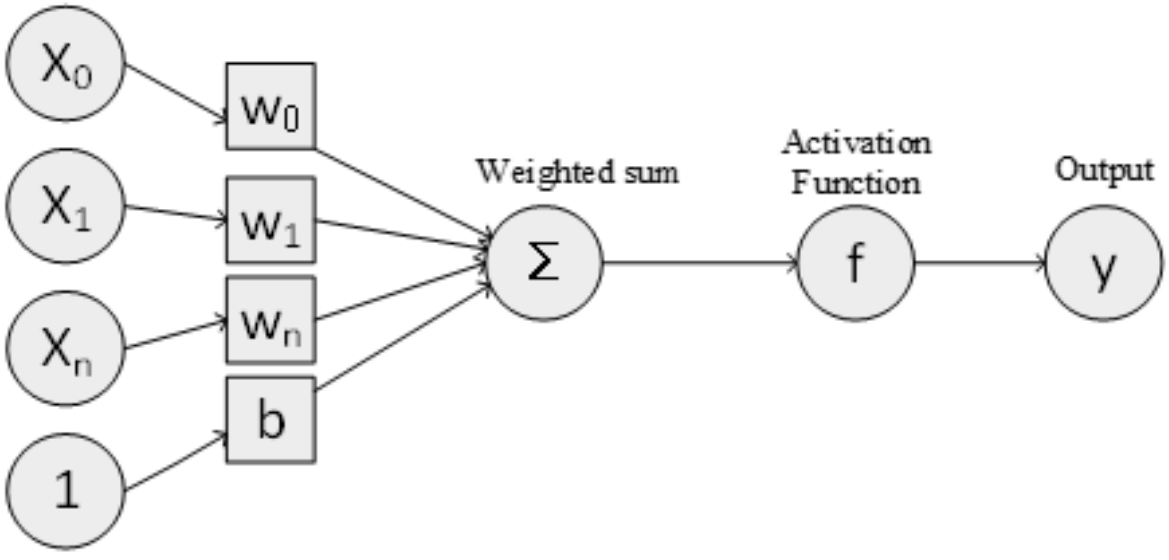

Fig 5. Artificial neural network diagram.

The general equation of its linear model is:

$$\hat{y} = f(w[0] \bullet x[0] + w[1] \bullet x[1] + \cdots + w[n] \bullet x[n] + b) \quad (1)$$

Where y-hat denotes the estimate of y, X_0 to X_n are the sample feature values, W is the weight of each feature value X, and f is the function that activates the output of the hidden layer neurons. The commonly used activation functions are relu, tanh and sigmoid. The activation function used in this paper is the hyperbolic tangent function tanh, whose formula can be expressed as

$$\tanh x = \frac{\sinh x}{\cosh x} = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}} \tag{2}$$

4.2. Multi-layered sensors

Multi-layer perception (MLP) is a feedforward neural network that maps a set of input vectors to a set of output vectors. MLP can be a directional diagram of multiple layers of nodes, each wholly connected to the next. Except for input nodes, each node is a neuron with nonlinear activation. A supervised learning method called reverse propagation algorithm (BP algorithm) is a kind of generalization of perceptrons, which overcomes the shortcoming that perceptrons cannot recognize indistinguishable linear data.

MLP neural network consists of input layer, hidden layer and output layer. In the MLP model, the algorithm multiplies the weighted sum of 4.1 in the hidden layer and then generates the final result using the results of the hidden layer. As shown in Figure 6:

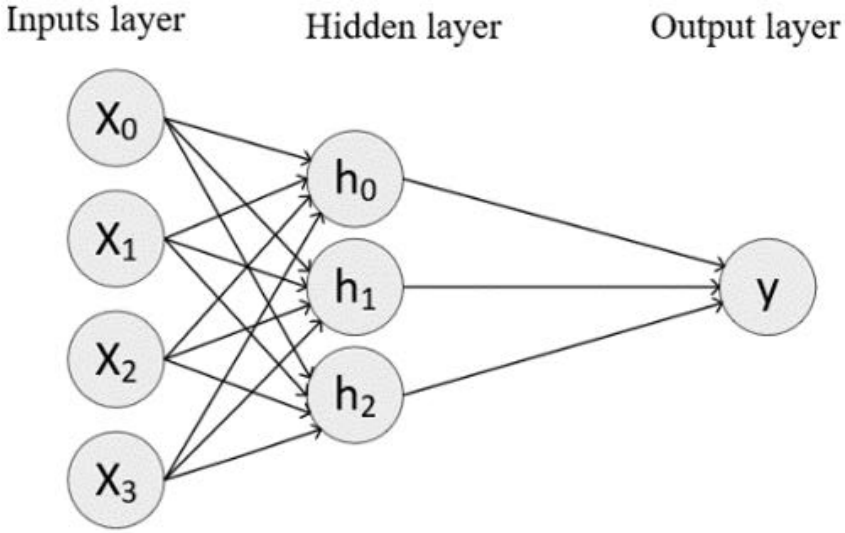

Fig 6. MLP model.

$$\begin{aligned} h[0] &= f(w[0]\bullet x[0] + w[1]\bullet x[1] + \cdots + w[n]\bullet x[n] + b) \\ h[1] &= f(w[0]\bullet x[0] + w[1]\bullet x[1] + \cdots + w[n]\bullet x[n] + b) \\ h[2] &= f(w[0]\bullet x[0] + w[1]\bullet x[1] + \cdots + w[n]\bullet x[n] + b) \end{aligned} \tag{3}$$

$$\hat{y} = v[0]\bullet h[0] + v[1]\bullet h[1] + \cdots + v[m]\bullet h[m] \tag{4}$$

v is the weight of the hidden layer h. Neural network structure is designed to solve the problem of how many hidden layers and how many nodes each hidden layer has. Deep learning is about increasing the number of hidden layers, or the number of nodes in hidden layers. w and v are learned through training and data.

5. Authentic Proof Analysis

5.1 Research Object Selection and Data Collection

This paper firstly constructs the index system of digital inclusive finance and real economy, determines the structure of MLP neural network, and takes the processed inclusive finance index as the input layer of MLP neural network. The neural network randomly divides the output data into training samples and test samples according to a certain proportion. According to the nonlinear relationship between input layer and output layer of training sample, training and learning are carried out, and the weight of each neuron is automatically adjusted to establish a specific functional mapping relationship. Test samples were then used for testing. The specific process flow is shown in Fig. 7.

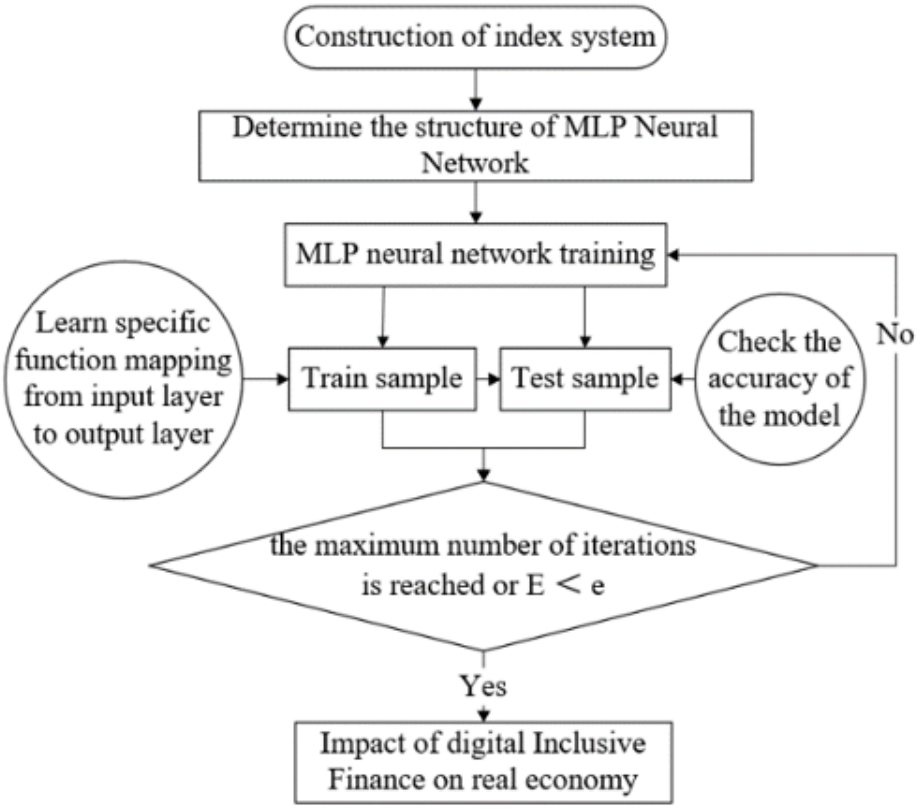

Fig 7. MLP Neural Network Model Process of Digital Inclusive Finance Impact on Real Economy.

5.2 Importance Analysis

Based on the data collected, to explore the impact of digital inclusion finance on the development of the real economy, the input layer consists of the total index, coverage, depth of use and digitization of the aforementioned digital inclusion finance. The output layer is composed of five indicators mentioned above, including the GDP of the real economy, the added value of the secondary industry, the investment in fixed assets, the power generation and the freight volume. Five neural network pieces of training are carried out through the MLP multi-layer perceptron, and the influence and importance of the input layer are quantified by measuring the prominent weight. The influence of the input layer on different real economic indicators is shown in Figure 8 – 13.

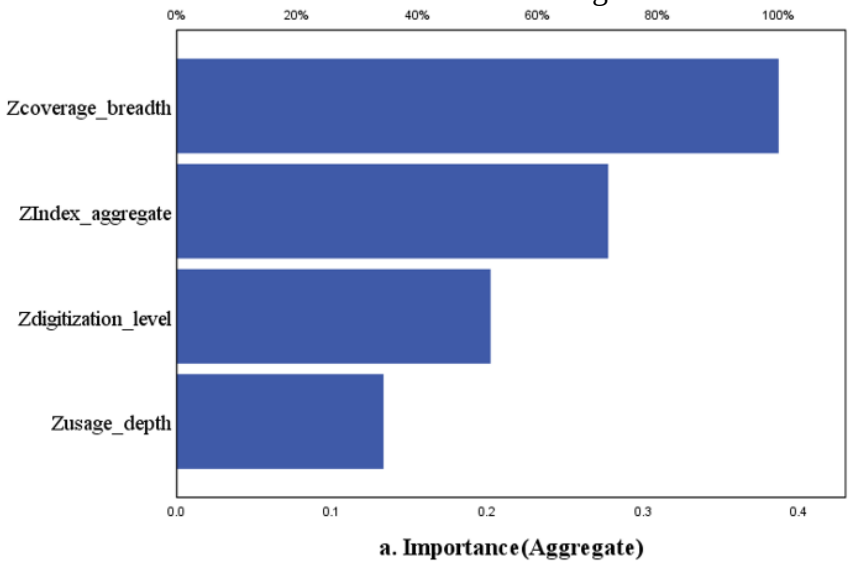

Fig 8. Importance (Aggregate).

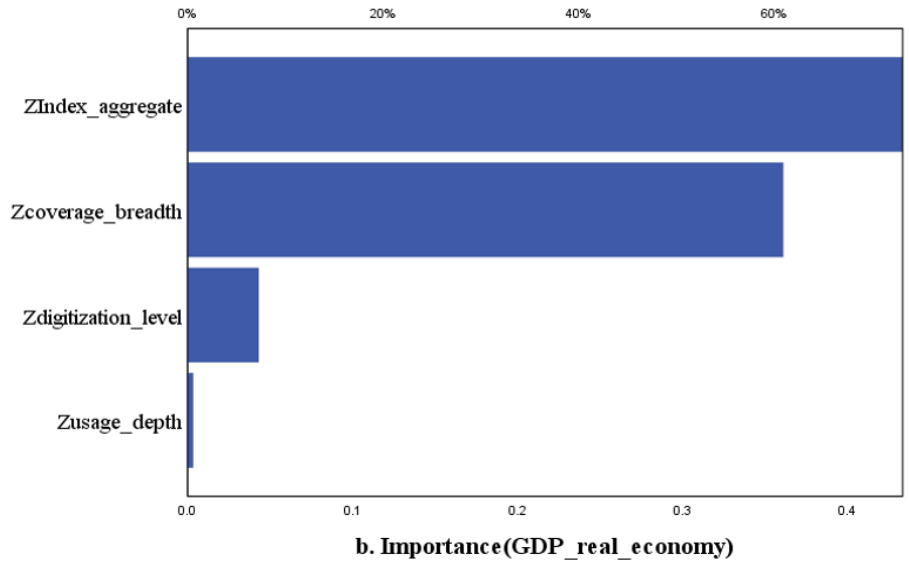

Fig 9. Importance (GDP_ real_ economy).

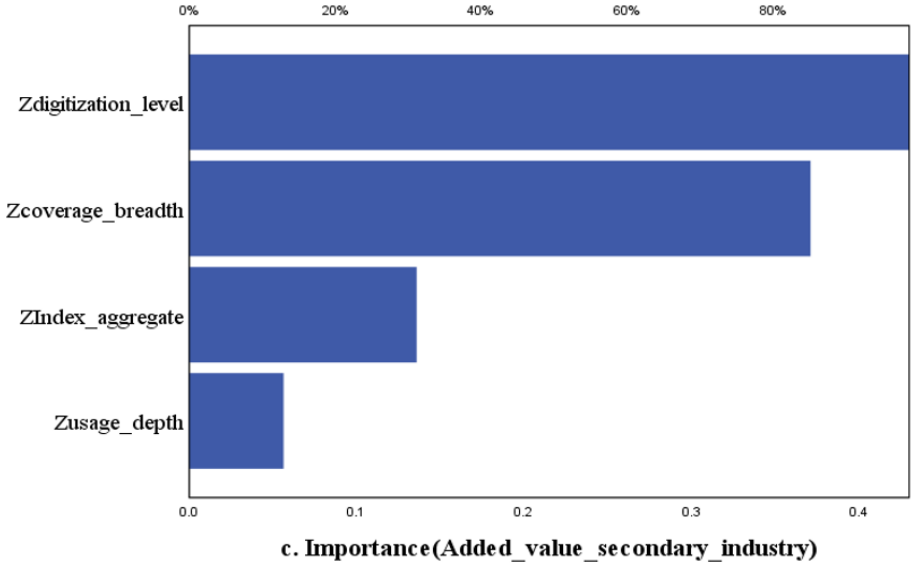

Fig.10 Importance (Added_ value_ secondary_ industry).

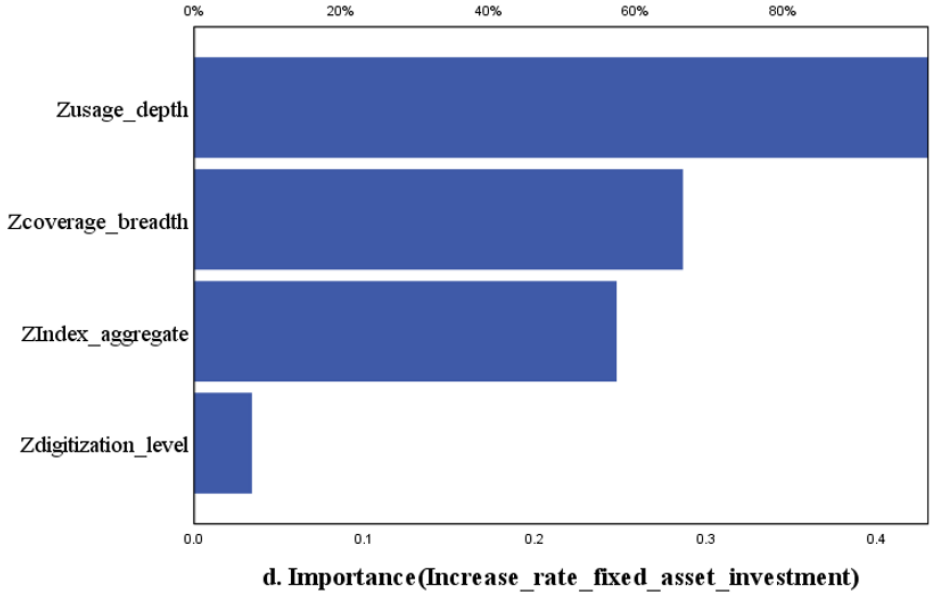

Fig 11. Importance (Increase_ rate_ fixed_ asset_ investment).

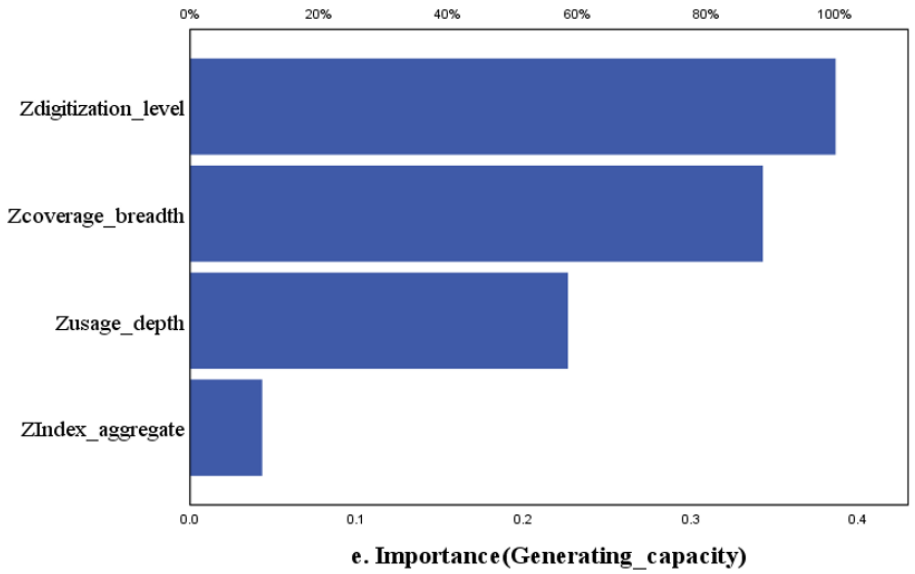

Fig 12. Importance (Generating _ capacity).

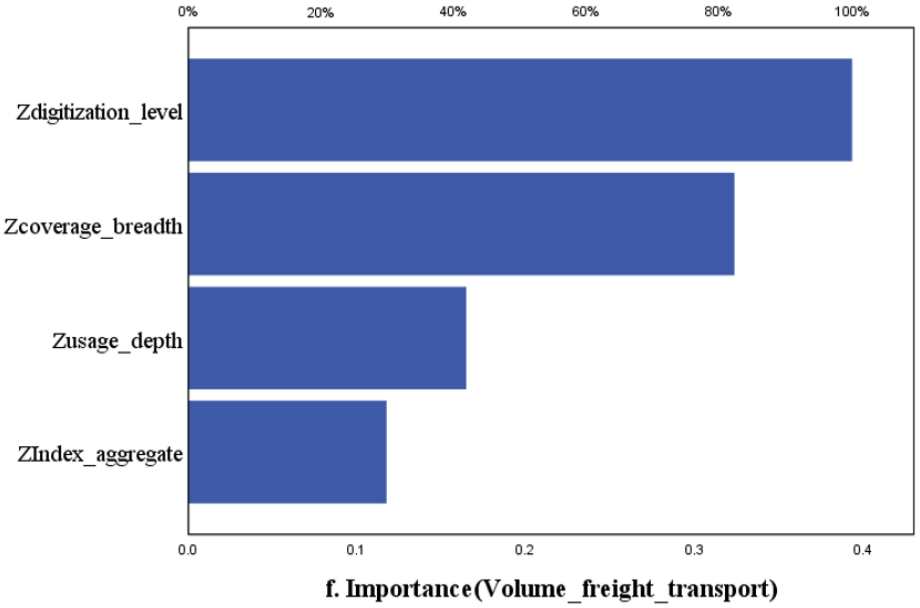

Fig 13. Importance (Volume _ freight _ transport).

According to the results of importance analysis, for the output layer as a whole, the coverage width has a more important impact than other output layer indicators. At the same time, in the importance analysis of five different indicators, the digital inclusive financial index has an essential impact on the real economic gross product; the extent of digital discourse has a significant effect on the proportion of the secondary industry; the depth of application of digital inclusion finance is more important for the added value of the fixed-asset investment; digital inclusion has a bigger impact on power generation and freight traffic.

According to the results of the importance analysis of MLP neural network, digital inclusive finance is important for promoting the development of the real economy as a whole. Inclusive finance, represented by digital inclusion finance, meets the financial services needs of low-income and vulnerable groups. Expanding access to digital inclusive finance can effectively mitigate financial exclusion and allow more people and businesses to have reasonable access to the financial products and services they need. At the same time, expanding the coverage of digital inclusive finance can ease the liquidity constraints of consumers and small and medium-sized enterprises through new resource allocation, smooth consumption over time, expand consumer demand and promote real economic development.

Digital inclusive finance is of great significance from the point of view of the value-added ratio of secondary industry. With the rapid development of Internet-based digital inclusion finance and mobile payments, the availability of corporate financial services has increased and the demand for financial services has shifted to SMEs. At the same time, the information collection and processing brought about by digital financial services will help to alleviate the information asymmetry and improve the ability of all people to identify financial risk; digitization will ease the financing constraints of small and medium-sized enterprises by widening the financing channels, reducing the financing costs and improving the financing efficiency. Therefore, the digital level is of great significance for financing secondary industries such as manufacturing, especially inclusive conglomerates.

For the growth of fixed-asset investment, the deep application of digital inclusive finance is of great significance. According to the structure of Peking University's financial inclusive index, the use depth index consists of payment service, insurance service, credit service, money market fund service, investment service and credit service. Thus, the use of the depth index represents the level of business development of digital inclusion finance.

For SMEs in the early stages of development, especially those with a high proportion of fixed assets and a large scale of investment, the convenience, timeliness and inclusiveness of digital inclusive financial operations have improved enterprises' financing channels and efficiency and promoted resource allocation and investment practices. (Yi & Zhou, 2018, 47-67)

For the two indicators of power generation and freight volume, the level of digitalization is more important. According to the McCallum and Goodfriend (1988) purchase time model, the motivation of holding money is to facilitate the purchase. For consumers or residents, the digital level of digital inclusive finance reduces the transaction cost and time cost of consumer financial services, thus promoting consumer behavior from two aspects of convenient payment and credit convenience, which is of great significance to the improvement of consumer freight volume in the real economy. In addition, the improvement of the digital level of financial services acquired by enterprises has also expanded investment behavior by increasing liquidity and easing cash flow pressure, so that power generation and freight volume are reflected.

6. Conclusion

This paper mainly uses MLP neural network algorithm to construct and analyze digital inclusive finance index and real economy development index and verify and analyze Beijing's actual data. In this paper, the data mining function of MLP neural network is applied to the research of the influence of digital inclusive finance on the development of real economy for the first time.

Through the adaptive learning of neural network under nonlinear and non-parametric conditions, this paper obtains the indicators that significantly impact the real economy in the digital inclusive financial index. Analysis of the importance of neural networks shows that digital inclusion finance is important in terms of the breadth of coverage for the real economy as a whole, which is also influenced by the degree of digitization and usage. In particular, the development of digital inclusion finance plays an important role in most indicators. Digital level reduces liquidity constraints of consumers and SMEs, improves financing efficiency, broadens financing channels, reduces financing costs, facilitates payments by consumers and enterprises, and promotes the development of the real economy.

Authors' contributions

Rongyang Li, writing for Abstract, introduces and analyzes the current situation of Digital Inclusive Finance Index in Beijing;

Siqi Li contributed to the construction of the regional real economy development system and the introduction of the ANN-MLP;

Haoyu Wangzhang conducted data analysis and contributed to constructive discussions.

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Siqi Li
Haoyu Wangzhang

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